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ABSTRACT

This paper describes the continuing development of a computer assisted instruction system that will connect the computer and a video storage device so as to allow the computer to regulate the delivery of instruction to individual television terminals. The video storage device consists of a videodisc player which feeds television signals from 60 minute "phonograph record like" discs. A cost analysis as well as proposed research procedures and hypotheses are included. (STS)

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# FUTURE REVIEW OF CAI AND THE COMING OF VIDEODISK TECHNOLOGY

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## INTRODUCTION

The purpose of this paper is to describe the development of a Computer Assisted Instuction System that will link television systems and computer systems together by means of a mini-computer network that will be tightly tied to a maxi-computer. Such a combination will connect the computer and a video storage device in such a way as to allow the computer to regulate and monitor what has been delivered to each individual television terminal. Each terminal will deliver what a television camera has seen on the basis of student determined needs. The logic of such a system will be controlled by the mini-computers and the goverance of the entire network would be under the control of the maxi-computer. With such a system, interactive color television systems could furnish a type of Computer Assisted Instruction (CAI) that has been envisioned by its early pioneers but never realized.

A series of developmental procedures and experimental studies are about to begin to test the following hypotheses:

(1) If a maxi-computer can support CAI, then the maxi can be interfaced with a mini-computer in a distributed processing mode.

(2) If a maxi-mini computer interface can be accomplished then the maxi-computer can translate and transmit CAI courseware in a format that can be executed by an executive routine that is resident within the mini.

(3) If a mini-computer can support an interactive computer terminal, then it can support a video disk peripheral.

(4) If a mini-computer can support video disk peripherals, then CAI courseware can be transmitted to a keyboard-interfaced-television receiver via the video disk.

(5) If an instructional logic is programmed into a large digital computer (maxi), then the maxi can direct and monitor CAI courseware delivered by mini-computers to a video-disk supported television terminal.

The above hypotheses will be tested using selected mathematics, statistics, reading, Spanish, biology, behavioral science and other curriculum materials with elementary, secondary and undergraduate and graduate students. The instructional materials will be delivered by a mini-maxi CAI communications and distributive processing network to a variety of interactive terminals including a video disk support television terminal.

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Courseware requiring interaction with highly visual materials such as chemistry, biology, anatomy, cell biology, behavioral science will be generated to test effectiveness of the instructional logic and the video disk supported television terminal. Various types of experimental designs will be used to investigate the hardware network designs and its dependent variables which determine its effectiveness aspects, such as cost per hour, course preparation cost, student achievement, educational effectiveness, etc.

## Conceptual Need for the Proposed Research

The increasing integration of computers and communications into a single system has led the way in expanding the distribution of Computer Assisted Instruction to a wide variety of instructional institutions at all levels of the education continuum. Unfortunately, the cost of distributing this valuable instructional tool has not decreased proportionately with the decrease in computer hardware costs due in large part to the increase in communication costs. One way of distributing this computer assisted instruction and avoiding the increasing communications cost is through the technological technique known as distributed processing. Distributive processing in this case is the technique of connecting a large (host) computer to one or many mini-computers where each mini-computer is able to support several terminal users. Each of the mini sites is independent of the other, but all have the ability to communicate with the host computer. In this application such a communication system is necessary to provide a high performance mini-computer solution for terminal-intensive CAI systems.

In addition to the communication needs there is a pressing demand to provide a much more responsive and cost effective method for providing audio/video/graphic programming. In order to do this there must be a technological advancement that will provide information transfer at a higher level than is currently available. This need is created by three obvious requirements of an instructional system:

(1) the ability to generate, program and edit interactions with complex real images,

(2) a technique for creating and delivering cost-effective graphics and visuals that allow for interaction and recreation.

(3) the capability to provide overlays on images for sequential question frames. Such questions need to be communicated by audio or visual messages.

Such requirements call for the creation of a distributed processing video disk interactive system that will provide such capabilities to any location capable of receiving a television signal.

## RELATED RESEARCH

### Statement of the Problem

Part of the communication problem stems from the need to distribute CAI course material from large computing systems to multiple sites using numerous independent long distance lines. As remote locations increase in number and distance from the large computer so do the communications costs. A mini-computer at a remote site would cut the communications costs but it also severely limits the type and number of CAI materials available to the site because of the limited processing of mini-computers. Another vitally important element which needs to be developed for such a process is a sophisticated CAI language, to program and execute CAI courses, which can be implemented on a mini-computer. Present large systems have this capability. However, if one were to utilize a large computer at each CAI site, then the cost of the hardware and duplication of software and staff support would make the widespread use of CAI economically impossible.

What is needed, therefore, is a means of integrating large and small computers for the purpose of conducting online, as you need it, interaction between large computers, smaller computers and interactive terminals. In this case the term online is used to mean ability to the user to interact with the computer on a continuous basis, through a terminal.

Present systems that integrate large and small computers deal only with remote batch processing operations when communicating with each other. (Remote batch processing is the technique of running computer programs in a deffered mode from a site remote to the main computer.) It is important to note that this process does not continuously interact with the host computer. What is needed is an intermittent, interactive, communication between large and small computers which allows the large computer to compile and communicate a CAI course in a format that the mini-computer can execute. To do this, a feedback technique which would allow the mini-computer to send student data and new course requests back to the large host computer for interpretation, file updating, and requests for course formulating, must be created.

Once such a system is available, the boundaries of CAI applications will no longer be dictated by the computer site but will be able to stretch economically across the various levels of the education continuum in various geographic locations. This would remove the barriers between levels of education and bring about a coordination and articulation that has long been needed but never delivered. One of the steps needed to achieve this goal will be provided by interfacing each educational level with all other levels. The key to success is a well planned curriculum that can be delivered in a controlled environment. CAI provides such an environment. A CAI network provides the economy and coordination that will make the goal achievable.

## The Need for Full Color Graphics

What has been described above is only one phase of the needed development for CAI systems. A second phase of development centers on the need for a continuous full color graphic capability that will allow video messages to be part of the CAI system. The means for creating such a capability has recently been developed and it is our belief that any terminal that becomes part of the proposed CAI network should be equipped with a video disk capability. By distributing the course logic and execution systems to remote sites from a host computer one also will have the capability of addressing several peripherals; one such peripheral should be video disk. The combination of video disks and distributed processing can provide a type of educational computer terminal network that could conduct two-way TV like instructional systems that would have all the preplanned system of instruction that CAI demands as well as the dynamic and vivid capabilities of today's best color TV systems.

The need for such a system has long been recognized by those who have labored long in the vineyard of CAI. Many topics are color and motion dependent. Examples of interest include chemistry, biology, cell biology, behavior science, fine arts and perceptual skills. Hence, an economically feasible color graphic system is needed. This system must be able to communicate effectively with a large host computer and it must do so in a way that will enrich the learner's experience more than the communications carrier. Because of the limited and costly nature of line generated graphics, most CAI is carried on with no or very primitive graphics. Furthermore, it is often more effective for the learner to be able to interact with, disect, analyze, and evaluate real images, such as provided by an interactive video disk terminal.

We believe that a distributed processing CAI system that incorporates the technology of computers and television communication techniques can be used to conduct two-way CAI-TV systems that will provide color graphic instructional material that adheres to the tenets of a learner controlled CAI system.

## Important Recent Developments

In recent years the University of Iowa, the Mitre Corporation, and Brigham Young University have developed the technology of CAI in the direction of a distributed processing video system. Unfortunately, neither project has sufficient resources to see the projects through to the goals described in the proposed project. The beginnings made by each of these past projects will be utilized in the design of this CAI project.

The preliminary work for the communications interface has already been done at the University of Iowa. This concept could be expanded from its present state (remote batch communications only) to a true

interactive processing type of interface.

The batch processing techniques used in the mini-maxi system work done at the University of Iowa would be utilized in developing the communications protocol for the distributed processing dispatch system needed in this project. However, there would be a great deal of new development needed to bring about a true distributed processing CAI system.

Since mini-computer hardware can only supply a limited amount of computing power and capabilities, the languages designed for instructional use of such machines are also limited in these capabilities. Such limitations often reduce the users' expectations to most primitive instructional strategies. For this reason it is necessary to provide mini-computers with the capabilities of an instructional language that has been designed for large system use. The technique for providing such a capability rests on the method of sharing a large computer's capability with a small machine through the technique known as distributed processing.

At present, The University of Akron utilizes the instructional program package provided by IBM, Coursewriter III. Since this project is based on the assumption that The University of Akron will supply the large computer facility and a large CAI course file, the language Coursewriter III will be the base language for the instructional logics in this project.

Because of the incompatibility of Coursewriter III language and languages available on mini-computers an executive would have to be designed and written that would be resident in the maxi system. This executive would interpret a Coursewriter III program into executable modules acceptable to the mini-computer. This translated language would be one that is available on a wide range of mini-computers, so as not to limit it to one vendor's hardware (computer). During the execution phase of the CAI program the mini would execute the program and develop a student record file which would later be sent to the maxi for file updating and statistical work. Thus preserving the necessary student data for both the administrative needs and course authoring feedback.

By utilizing such a technique, The University of Akron could, in a minimum of development time, deliver over two-hundred man years of developed CAI course material to local mini-computers which would transmit such courses to local users.

The experience of the Mitre Corporation and Brigham Young University on video transmissions and courseware design would be utilized for the development of the video disk system. This would be the second phase of the project. Once the distributive processing network had been established, the terminal sites would be upgraded to include video disk supported terminals.

One might ask, why not develop a stand alone video disk terminal and eliminate the computer costs all together. A casual investigation of video disk technology suggests that a stand alone video disk CAI system would be less costly. However, deeper investigation shows that there are several problems with a stand alone system.

One of the problems with a convential CAI system that does not exist with a convential CAI system is the permanency of the video disk medium. Once the video information is embedded on the disk, it cannot be changed since it is read only, similar to a standard phonograph record. The need then, is for a system that allows one to create, evaluate and modify course material before it is embedded on the video disk master. This could be accomplished on the mini-maxi system where course changes can be accomplished. This system will serve a dual purpose in that it can be used for delivery of video disk (production) CAI courses along with courses that are still not in their final form. This can be accomplished on the mini-maxi system using an intermediate video tape supported terminal for courseware development. A distributed processing type of system allows for student evaluation and author revisions without the cost of creating a new video disk master each time a revision is made to a course. Only after a course has been rigorously tested and evaluated will it be classified as a production mode course (i.e., placed on video disk). Also, since there is a great need for student performance data, the mini-computer alone would not suffice since it would become bogged down in record keeping tasks and degrade system response time. Quick response (under one second) is desirable in a viable CAI system. These reasons dictate the need for a mini-maxi configuration and a video disk CAI system to be economically feasible and also able to meet the needs of the students using the system. (i.e., it is probably more economical than a total distribution of a CAI function.)

It is important to note that the development of the Iowa mini-maxi interface did not provide for the down loading (process of taking courses from the maxi and making copies of them on the disk of the mini using the communication interface) of Coursewriter III courses from the maxi. What was provided was linkage that would allow a mini to be linked to a central large computer so that users could initiate jobs and transfer files to and from the central system while the mini was in a timesharing mode. Although this was a step forward in mini-maxi- computer communication, it left out one of the major necessities ofr building a true CAI mini-maxi network. The missing element was the needed online translation of courses and supporting functions for mini-maxi sharing. Since large systems have had a long history of courseware development it is vital that maxi resident courses be made available to the mini technology. What is missing on the minis is courseware!

Many claims are made by various mini users as th the availability of courseware but it is difficult to find a mini system that supports a large selection of well developed large courses. As a first part of this project the above problem would be solved. This proposed process would

Even a child could operate the videodisc player. The players feed television signals from 60 minute phonograph record like discs.

provide mini users throughout the world with a large block of sophisticated and proven courseware.

The Video Disk System

The interactive video disk system offers opportunities to combine research in psychology and education into new delivery systems for interactive individualized learning. We share the viewpoint of Cuppens and Ducot (1974) and Bennion and Schneider (1975) that these systems may have a great impact on the educational environment in the near future. In part, the reason for the promise that these systems hold is the increased capability they can provide. However, the most promising aspect of these future systems is the economy that may be realized through such systems. For example, a video disk can hold a great deal more information than is presently possible with magnetic disks. Therefore the amount of playing time that such a disk could provide would be sufficient to support most CAI systems. For this reason, "cost" will be the single most important ingredient in determining this system's success. A discussion of the costs of providing interactive instruction using video disks is in order. First, we shall discuss the hardware costs and then the courseware costs.

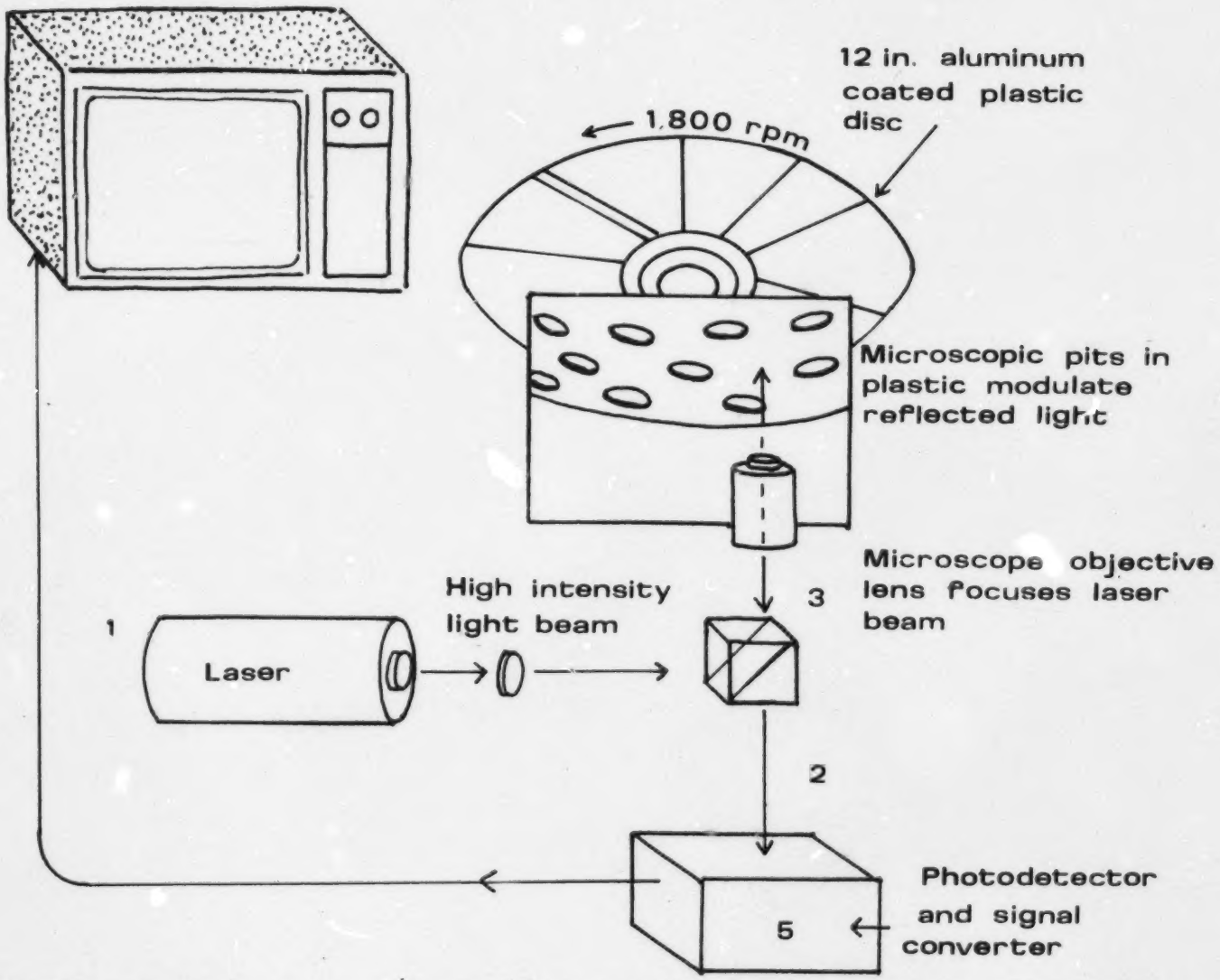
The interactive terminal consisting of a color TV, a video disk player and an interactive keyboard connected to an area mini-computer will probably range from $1,500 to $3,000 depending on the model and size of the TV and the complexity of the keyboard interface with the terminal and the mini. All four components are expected to have a long lifetime, hence, the cost per student hour is expected to be small compared to the cost of courseware development. One way of offsetting some of the courseware development cost is to modify appropriate existing courseware from the mini-maxi CAI system. Such an accomplishment could save thousands of valuable man hours. Of course, there will be many new courses developed as a result of the video disk's capability. One reason for this is that the problem of coding graphics on a line by line basis would no longer exist and the limits of the computer's encoding system would be broadened.

An important system application that permits this broadening is the storage of file related data. This data can be text or pictorial in nature, or a combination of both. This type of file material can easily be indexed, with each frame on one disk or on a sequence of disks being tagged with a unique number in one of its vertical retrace intervals. These intervals will provide the vertical synchronization for the video signal. An embedded indexing code in this interval would not appear on a standard television display. Retrieval would be automated and carried out under either local mini-computer or remote maxi-computer control.

Such video or data related files could be randomly retrieved and camera created. The most primitive level of instructional use of such a

# How the Videodisc Player Works

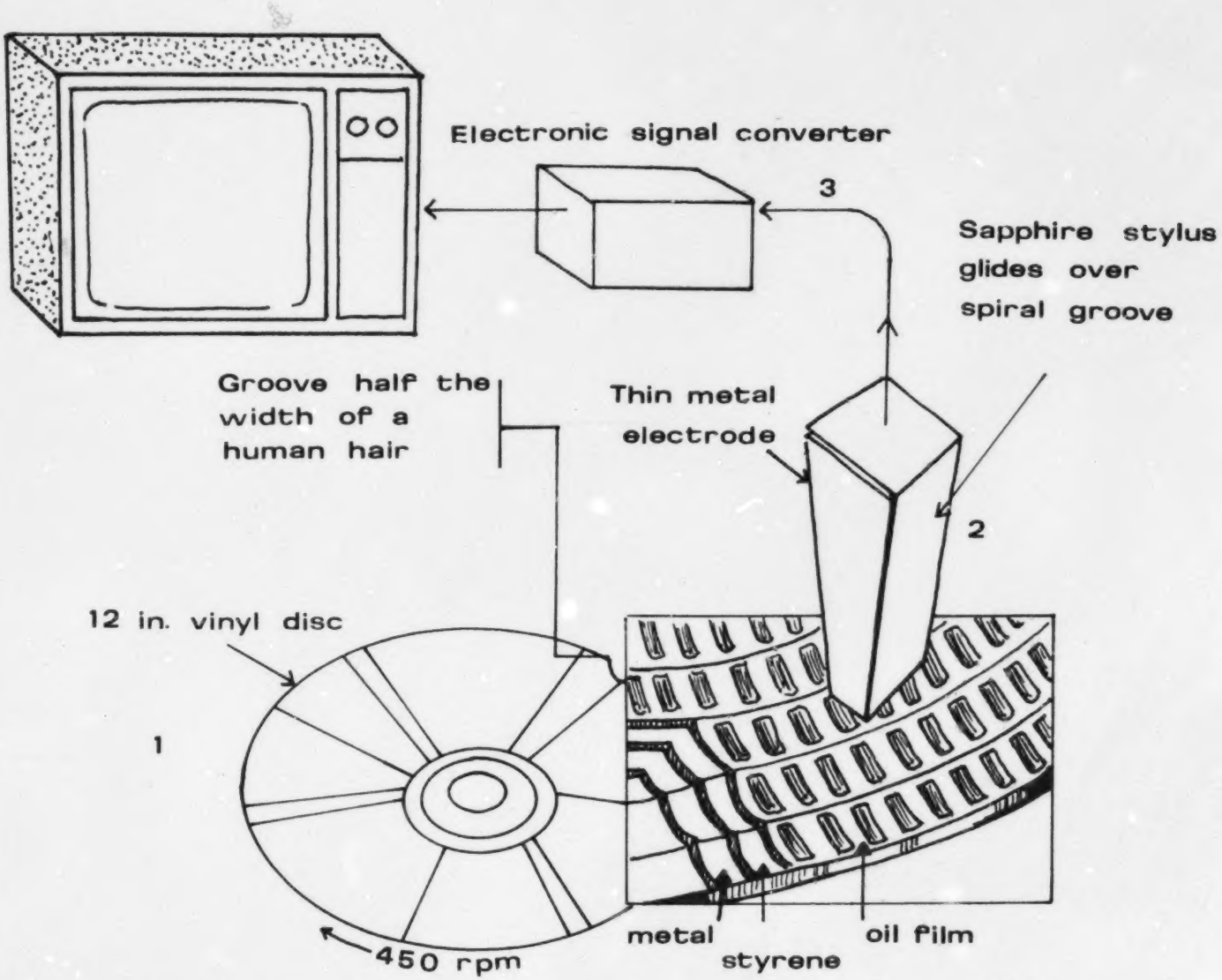
## Philips MCA Discovision player




**OPTICAL PICKUP** A laser(1) generates a light beam aimed by a prism(2) and focused by a lens(3) on a disc(4) coded for picture and sound. Reflected light strikes a photodetector(5) that converts it to signals that are processed and fed to a TV set.

# How the Videodisc Player Works

## RCA videodisc player




ELECTRICAL PICKUP The picture and sound code on a spinning disc (1) is picked up electrically by a stylus (2) that transfers signals to a converter (3). The converter processes the signals into electronic form accepted by a TV set.

medium would be to use the video disk and player as a simple training device. Physical actions and verbal instructions can be demonstrated and repeated in great detail either continuously or over and over, at the request of the using student. The courseware material can be segmented into a programmed sequence, with progression through the sequence under student control. More advanced tutorial applications could be delivered and monitored under computer control. The sequence would be determined by interaction between the student and the computer: questions, examples, rules and graphics would be generated and selected from the courseware material that was addressed and stored on the disk. Each sequence would be presented to the student at appropriate decision points. At the next level of sophistication the computer would evaluate the student's responses and would determine through its programmed course logic what sequence of disk information would be appropriate for such a response. In such a way the student's performance would determine the learner's sequence through the material. It is important to note that many of these audio visual, full color sequences would involve only very limited numbers of copies of disks on a given subject unless the material could be standardized for wide scale distribution. Hence, production companies should be formed to provide optimal marketing strategies for well developed interactive full color video systems. This is the CAI world of the future -

As you can see, the CAI world will become a full color video environment which will be as real as today's greatest cinematographers and animators can make it. In addition to these spectacular possibilities, there are some significant savings that can be made due to the video disks' single frame capabilities. By means of storing text information on a single frame, much of the CAI course text material could be removed from the computer and placed on the video disk thus minimizing the work done by the computer. This means that the number of terminals connected to a single mini could be increased significantly and hence the number of users on a single large system would be maximized, thus cutting valuable computing and communications time exponentially. Computing cost would be a minor portion of the CAI system.

## Cost Analysis

Bennion and Schneider (1975) point out that such a terminal, if operated for 20 hours per week for 5 years, would have a running time of 5,200 hours. MCA has indicated (Broadbent, 1974) that the laser used for playback can be expected to operate for 9,000 hours. If the other components, i.e., the mini, the keyboard, and the TV, also operate without frequent down time, the cost of the instruction due to the hardware would be in the order of 40 to 70 cents per hour. However, if a course were to make use of several motion displays the above cost would increase.

If we assume that

(1) Each still frame is viewed for an average of 10 seconds (or 360 frames per hour).

(2) Each still frame is supported by one other frame that is used for digital codes, i.e. 720 frames are needed for one hour of frame instruction.

(3) The estimated production costs to make a single video disk from a video tape master are $500 and drop to $1.00 per disk for large quantities.

$$\text{Production Costs} = \frac{\$500}{\text{number of copies}} + \$1.00$$

With the above assumptions

$$\text{Cost of Inst/Hr} = \frac{1}{\text{Hours of Instruction}}\left[\frac{\text{Development Costs}}{\text{Number of students}} + \text{Production Costs}\right]$$

If we assume that only one side of the disk is read, then the following algorithm will produce cost/hr.

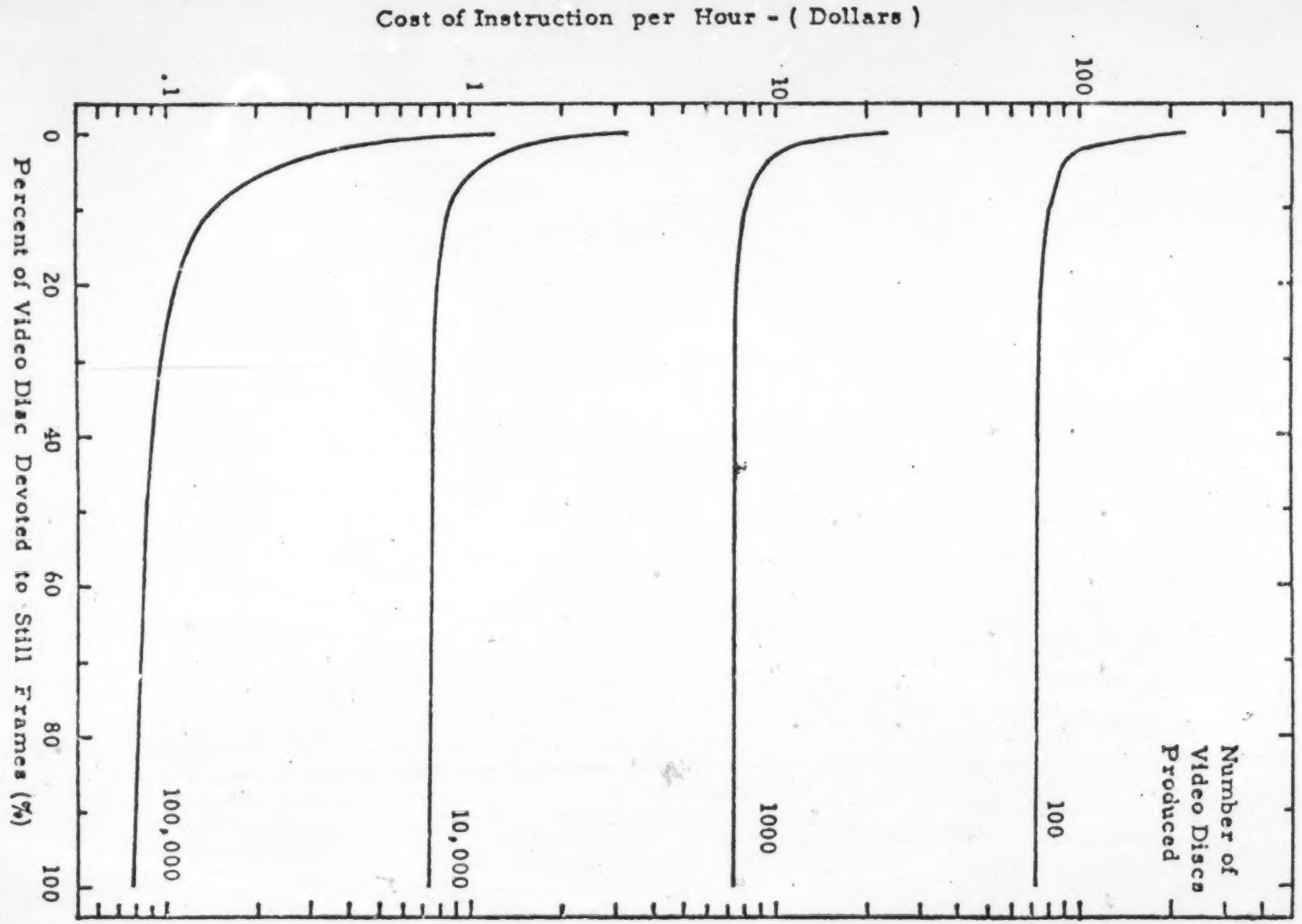
$$\text{Cost/Hr} = \frac{1}{1/2(1-\%SF/100)+\#SF/720}\left[\frac{(\#SF)(SFC)+(\#MF)\ (MFC)}{\text{market size}} + \text{Production Costs}\right]$$

where

#SF - number of still frames on disk
#MF - number of motion frames on disk
%SF - percent of still frames on disk
MFC - motion frame production costs
SFC - still frame production costs

The above implies that if all frames are motion frames the cost of CAI would be twice the cost of the number of motion frames times the cost per motion frame plus the development costs divided by the number of student users plus the production costs. The moral of this message is that motion is expensive. Hence, still frame graphics with no or small motion sequences lead to efficiency.

Bennion and Schneider (1975) assign the following costs for development of still frames (SFC) and motion frames (MFC). They calculate hourly costs of instruction for a variety of market sizes. They have done this for market sizes of 100, 1,000, 10,000 and 100,000 video disks, using SFC=$10 and MFC=$0.20. The cost per 100,000 student hours would




The Hourly Cost of Interactive Instruction as a Function of Market Size and Ratio of Still Frames to Motion Frames.

be less than seven cents per hour. We question the $10 development cost of still frame. Much of this could be reduced if existing materials and graphics could be reproduced. If such savings can be made, then the cost per student hour might well be more dependent on electric power costs than on system costs.

Objectives of the Project

(1) To provide the education industry with a CAI resource that conforms realistically to its budgetary constraints.

(2) To develop an interactive network of CAI stations that is served by means of a distributed processing network.

(3) To develop a software interface that will translate existing Coursewriter III courses into a compatible mini computer language that will permit interactive communications between mini and maxi-computers for course down loading and maintenance of student files.

(4) To develop an interactive CAI video terminal that will have a video disk interface and a mini computer local connection that is part of a distributed processing network.

(5) To evaluate existing hardware capabilities as to compatibility and cost effectiveness as components of a distributed processing video disk CAI network.

(6) To determine the most effective type of terminal(s) for video disk related CAI.

(7) To determine the most effective type of terminal-system configuration of video disk related CAI.

a) clustered on a mini-maxi system
b) distributed on a mini-maxi system
c) clustered on a mini
d) distributed on a mini
e) clustered on a maxi
f) distributed on a maxi

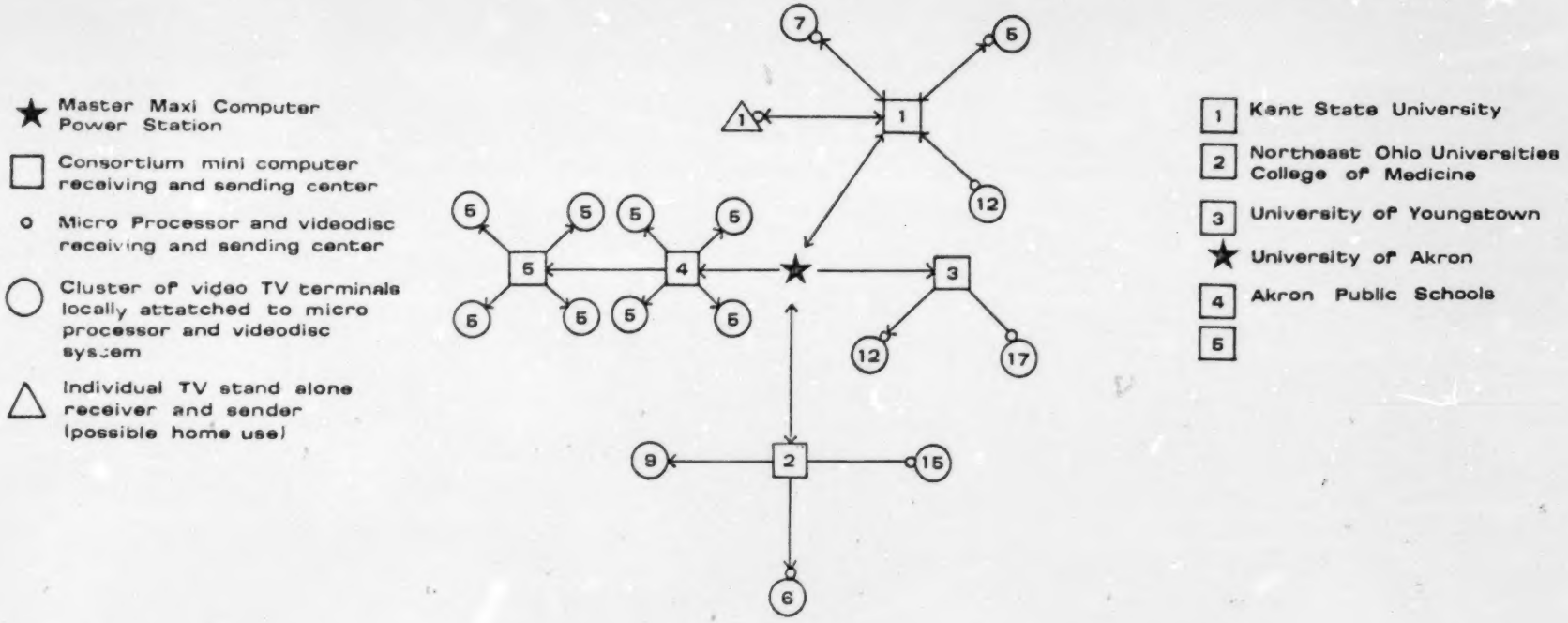
NETWORK DESIGN

| HARDWARE CONFIGURATION | clustered | distributed |
|---|---|---|
| max-mini | (a) cmm | (b) dmm |
| mini | (c) cmini | (d) dmini |
| max | (e) cmax | (f) dmax |

COMPUTER-TERMINAL INTERACTION MATRIX

| | MINI | MAXI | VIDEO DISK | CATHODE RAY TUBE |
|---|---|---|---|---|
| MINI | (Mini, Mini) | (Mini, Maxi) | (Mini, VD) | (Mini, Crt) |
| MAXI | (Maxi, Mini) | (Maxi, Maxi) | (Maxi, VD) | (Maxi, Crt) |
| VD | (VD, Mini) | (VD, Max) | --- | (VD, Crt) |
| CRT | (Crt, Mini) | (Crt, Maxi) | (Crt, VD) | --- |

Selected pairings of hardware will be evaluated by measuring the variance on the eleven listed dependent variables.


Master Maxi Computer Power Station
Consortium mini computer receiving and sending center
Micro Processor and videodisc receiving and sending center
Cluster of video TV terminals locally attatched to micro processor and videodisc system
Individual TV stand alone receiver and sender (possible home use)
1 Kent State University
2 Northeast Ohio Universities College of Medicine
3 University of Youngstown
University of Akron
4 Akron Public Schools
5

The Maxi Mini Computer
Videodisc Network

## DESCRIPTION AND PROPOSED RESEARCH PROCEDURES AND HYPOTHESES

### Independent Variables

A network design can be categorized as a hardware configuration of central processing unit(s), a communications system, and student work stations. The student work stations may be interactive terminals and/or remote batch terminals, each of which bears a particular relationship to the type of computer task to be performed by the user and the geometric arrangement of links and nodes in the network. A by-product of the proposed project will be verification, extension and refinement of the integrated network designs.

The following is a brief categorization of the six types of hardware configurations which can be characterized as independent variables.

(1) Terminals with video disk capabilities clustered on a maxi-max computer network (five or more terminals in a single location).

(2) Terminals with video disk capabilities distributed (stand alone) on a mini-maxi-computer network.

(3) Terminals with video disk capability clustered on a mini-computer.

(4) Terminals with video disk capabilities distributed on a mini-computer.

(5) Terminals with video disk capabilities clustered on a maxi-computer.

(6) Terminals with video disk capabilities distributed on a maxi-computer.

It is proposed that terminals without video disk capability be compared with video disk equipped capabilities in the set of computer related communication interrelationships for purpose of determining the disks' effect on building, using and distributing CAI course material to scattered students over a 50 mile radius.

### Dependent Variables

The effect of manipulating the computer and terminal configuration will be observed by measuring the variance on at least ten classes of dependent variables: (1) preparation costs (course design and creation), (2) delivery costs (cost per student hour), (3) hardware costs (computers,

communication gear and terminals), (4) maintenance cost (monthly charges for hardware and software preventive maintenance), and (5) systems reliability (i.e. actual percentage of scheduled hours the system is operating without failure). In addition to these technological cost considerations, (6) the effects on student learning will be measured based on achievement to specified criteria (quality control), (7) interest in course material, (8) willingness to explore (willingness to take an intellectual risk), (9) utilization of available facilities (how much use students make of the system), (10) staff savings (based on projected cost of adding staff to meet achievement levels obtained on the CAI system, i.e. necessary class size for similar achievement. This will be measured in terms of cost avoidance rather than cost reduction).

Hypotheses to be Tested

All of the above proposed observations are dependent upon the success obtained in supporting the following major hypotheses:

(1) If a maxi-computer can support CAI, then it can be interfaced with a mini-computer in a distributed processing mode.

(2) If a maxi-mini-computer interface can be accomplished, then the maxi-computer can translate and transmit CAI courseware in a format acceptable to the mini for distribution to standard CAI terminals.

(3) If a mini-computer can support an interactive computer terminal, then it can support a video disk peripheral.

(4) If a mini computer can support video disk peripheral, then CAI courseware can be transmitted to a convential television receiver via video disk.

(5) If an instructional logic is programmed into a large digital computer (maxi), then the maxi can direct and monitor CAI courseware delivered by mini-computers to a video disk supported television terminal or a standard CAI terminal.

Designs

The hardware network design will be the independent variable and the ten dependent variables will be as listed, i.e., achievement, cost per hour, preparation cost, etc.

Various experimental designs will be used to investigate the variables described above. These will involve pre-post test control group or post test only control group designs where applicable.

Some of the proposed investigations will also use within-subject controls in which various treatments (i.e. hardware configurations) will be compared to cost (i.e. factorial designs). Within-subject designs should be feasible if the type of content and course structure is a primary determiner of cost per student hour.

Analysis of data will use one way analysis of variance and regression techniques where appropriate.

Intermediate Prototype Products

Due to uncertain production schedule of the video disk manufacturer, system prototyping will be done with commercially available equipment such as Telemation .... Fortunately the uncertain production schedule does not cause the purchase of unnecessary equipment (video tape) since this equipment is also needed to generate and edit the video tape used for production of the video disk master. Two units would permit full prototype system testing. Conversion to video disks will be made when such units and their digital controllers become available (anticipated fall 1978).

The above development will call for two Telemation..., including video monitors. The disk development will require four video disks and their ancillary monitors and interface.

In addition to video monitors, special television receivers with input/output keyboard will be required. Four such units will meet the needs of a prototype model.

For purpose of creating the video inputs, a video camera that is compatible with the Telemation record/replay unit will be required.

The reason that such tape units are not proposed for the overall system is due to the high wear/maintenance levels and the restrictive access time that such units provide are limited.

Final Prototype Products

The primary product of this research will be a prototype computer assisted instruction network that supports video disk enhanced television compatible terminals. In addition to this there will be a substantial number of courses developed for support of CAI network

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